REMEDIATION OF LEAKING UNDERGROUND STORAGE TANKS (UST)

DESCRIPTION

This emission estimation guidance addresses volatile organic compound (VOC) air emissions from the remediation of leaking underground storage tanks, or USTs (SCC 26-60-000-000). A UST is defined as any one or a combination of tanks that have 10 percent or more of their volume below the surface of the ground (EPA, 1998a). This definition includes the tank, connected underground piping, underground ancillary equipment and containment system. These tanks typically have fixed fill pipes that discharge at the bottom of the tank. Depending on the number and size of the remediation events in an area and the inclination of the agency, UST remediations can be treated as a point or area source category.

Leaking USTs are typically not considered a quantifiable source of air emissions until excavation and remediation efforts begin. The majority of air emissions from leaking UST site remediations occur during initial site action, which is typically tank removal. During tank removal, the leaking tank and the surrounding soil are removed and the soil is either treated on-site to remove the contamination or transported off-site for treatment or disposal in a landfill. Emissions from soil occur as the tank is being removed and when soil is deposited on the ground before treatment/disposal occurs.

The magnitude of VOC emissions during remediation events depends on several factors, most all of which are specific to each remediation site. For this reason, determining emissions for this activity is a difficult and complex problem. Factors influencing VOC emissions from soils include the type, concentration, and distribution of contaminants in the soil, the porosity and moisture content of the soil, temperature, wind, shape and surface area of soil piles, the type of soil handling equipment used, and the duration of the operation (EPA, 1989; EPA, 1997).

Different contaminants and their constituents have varying vapor pressures which affect the rate of volatilization and movement through the soil. The ability of contaminant vapors to move through the soil depends on how large and continuous soil pore spaces are. The presence of increased moisture in the soil will also inhibit vapor movement and eventual air emissions. Contaminant vapor pressure is highly dependent on temperature - increased temperature means higher volatilization. Higher wind increases the rate of volatilization because it increases the flux of vapors from the soil pores into the surrounding air. Pile surface area is directly related to emissions - greater area equals higher emissions. Soil handling methods influence emissions by affecting the physical treatment of the soil (e.g., vigorousness of movement, drop heights, etc.), which in turn impacts emissions (EPA, 1989; EPA, 1997).

The rate of VOC release from soils during remediation events is highly variable (EPA, 1989). Although specific numbers are not available, most research on soil remediation activities has shown that the majority of VOC contaminants is volatilized during the first few days of the remediation event. There is an initial burst of emissions in the first 3-4 days to 2 weeks of activity followed by an exponential decrease to negligible levels (EPA, 1989; EPA, 1997).

Information concerning the specific parameters of USTs may be retrieved from state UST program offices. On the Internet, one resource developed by the Delaware Department of Natural Resources and Environmental Control (DNREC) is the “Underground Storage Tank Information Locator” (Delaware DNREC, 2001). Linkages to regulations and individual state regulatory agencies are available at this site. For states without UST program offices, information may be found at state offices that monitor water and groundwater pollution; hazardous materials and solid wastes material storage; and oil and petroleum storage and safety. The EPA Office of Underground Storage Tanks maintains a website at www.epa.gov/swerust1/ (EPA, 1998c). Information contained at this site includes UST operation, maintenance, and cleanup guidance, UST laws and regulations, Frequently Asked Questions on USTs, compliance assistance, and application software for state agencies to build their own UST databases. Additionally, a list of EPA regional UST program managers and a list of state agency UST contacts is available.

POLLUTANTS

Volatile organic compounds (VOC)

AVAILABLE EMISSION ESTIMATION METHODS

The available methods for estimating emissions from leaking USTs have been developed for tanks that contain gasoline, and can be used for tanks with contaminants of similar volatility (EPA, 1992). The Preferred Method was selected based on the presumption that it provides the most accurate, source-specific emissions estimate for the remediation of USTs. The method addresses individual tank remediation events, and as such, does not conform to the orientation of traditional “area source” methods. To be used in an area source vein for a geographic area (e.g., county or nonattainment area), the individual applications of the method will have to be summed for all remediation events to give an emissions total for the area. Inventory preparers using this method could opt to report individual UST remediation sites as point sources if estimated emissions exceed point source threshold amounts.

The Alternative Method reflects more of a traditional area source approach in that the sum of an activity parameter (i.e., number of remediations) is multiplied by an overall average default emission factor to determine an area-wide emission estimate. Based on a user’s knowledge of their sites, additional information exists with the Alternative Method that allow a user to adjust the default factor to better mirror actual site conditions involving either volume of soil excavated or level of pollutant contamination in the soil. The ability to use the Preferred versus Alternative Method will be dependent on how much site-specific data are available on a remediation event and the availability of time and resources to collect such data.

PREFERRED METHOD

The Preferred Method involves the combination of several site-specific parameters in the following equation to estimate average ozone season daily VOC emissions. To apply the method, information has to known about the volume of soil excavated (e.g., cubic yards of soil), the density of the soil excavated (e.g., lbs/cubic yard), and the concentration (e.g., parts per million by weight (ppmw)) of VOC in the contaminated soil. These parameters are combined in the following equation to yield a VOC emission rate (ER) in lbs/day.

$$ER = \frac{\text{(Volume of soil excavated) * (Density of soil excavated) * (Concentration of VOC in the soil)}}{\text{Number of site remediation days involving soil excavation and treatment}}$$

The equation determines the total amount (pounds) of VOC contained in the excavated soil and assumes all of this amount is released to the air over the duration of the remediation. As was described previously, however, the bulk of actual emissions from a remediation activity occurs during the first few days and decreases significantly thereafter. Application of this procedure will calculate an estimate of <u>average</u> daily ozone season emissions for a specific site. If a user is trying to develop an inventory estimate for the purposes of episodic ozone modeling, an approach other than the average daily method should be followed to account for the high first-day emissions from remediation events. Although no data or factors could be found to specifically quantify how much of total emissions the initial emissions burst constitutes, it is believed to be 5-10 times higher than emissions after 30 days (EPA, 1997).

It is important that the number of remediation days is determined correctly as this will affect the determination of average daily emissions. For the purposes of estimating VOC emissions from soils, the number of remediation days is defined as the amount of time from when soil is first disturbed to dig up a tank until all excavated soil has been treated or taken from the site for disposal. It is not the total number of days the overall site remediation process was active, since the overall process can include operations not related to soil excavation.

If the period of remediation does not all occur within the ozone season for the area, average ozone season daily emissions should be determined by using the number of remediation days actually occurring in the ozone season as the denominator of the estimation equation and not the total number of remediation days. If the method is applied to all remediation sites in the geographic area of interest and then the results summed, total daily emissions for the category in the ozone season can be determined.

An example illustrating the method is given below.

Example: ABC Oil company proposes to excavate 1,200 yd^3 of gasoline-contaminated soil. Composite soil samples showed an average level of 2,250 ppm total petroleum hydrocarbons (TPH) in the soil. Excavation is expected to be completed in 18 days. The excavated soil will be taken to a landfill. An average soil density for soils in the area was found to be 3,900 lb/yd^3 (Note that soil types and densities vary across the country. Data on soil properties in a given area can be found in soil properties reference books, U.S. Department of Agriculture and U.S. Geologic Survey publications, and state/local agricultural service publications.)

$$ER = \frac{\text{Volume} * \text{density} * \text{concentration}}{\text{Number of site remediation days}}$$

$$= \frac{1{,}200\ yd^3}{18\ \text{days}} * \frac{3{,}900\ lb}{yd^3} * \frac{2{,}250\ ppm}{10^6}$$

$$= 585\ \text{lb TPH/day}$$

If the volume of soil excavated at a given site is unknown, the following set of equations can be used for calculating this parameter in order to apply the Preferred Method.

$$V_{soil} = V_{ex} - V_{tank} \quad \text{[Equation 1]}$$

where:

V_{soil} = Volume of soil excavated (ft^3)
V_{ex} = Volume of total excavation (ft^3)
V_{tank} = Volume of the tank (ft^3)

V_{ex} and V_{tank} are calculated as follows (assuming circular tank/excavation):

$$V_{ex} = \pi(R_{ex})^2(L_{ex}) \quad \text{[Equation 2]}$$

$$V_{tank} = \pi(R_{tank})^2(L_{tank}) \quad \text{[Equation 3]}$$

where:

π	$\approx$	3.14
R_{ex}	=	Radius of excavation (ft) {This is the R_{tank} + radius of excavated soil surrounding the tank}
L_{ex}	=	Length of excavation (ft) {This is the L_{tank} + length of excavated soil surrounding the tank}
R_{tank}	=	Radius of the tank (ft)
L_{tank}	=	Length of tank (ft)

The radius of excavation factor (R_{ex}) may be a default value, based upon the site remediation standard operating procedure (SOP). For instance, if the SOP calls for excavating two feet around the tank, then the "R_{ex}" term will always be "R_{tank} + 2 feet".

Substituting Equations 2 and 3 into equation 1 yields:

$$V_{soil} = \pi(R_{ex})^2(L_{ex}) - \pi(R_{tank})^2(L_{tank}) \qquad \text{[Equation 4]}$$

The "V_{soil}" term is in cubic feet and can be converted to cubic yards by dividing by $27\frac{ft^3}{yd^3}$.

ALTERNATIVE METHOD

A more traditional "area source" method can be applied to estimate emissions from this category in cases where extensive site-specific data are not available. The method involves use of the number of UST remediations in the subject area and a default emission rate (per remediation) that is based on typical levels of gasoline contamination and quantities of soil removed, and theoretical flux rate equations using summer (ozone season) temperatures. The generic equation for the method is as follows.

Total ozone season daily VOC emission rate = Number of remediations * Default emission rate

The default emission rate is 28 lbs/day per remediation event and represents remediation activities with 50 cubic yards of soil excavated and a 10,000 ppmw TPH contamination level or 500 cubic yards removed at a contamination level of 1,000 ppmw TPH. The default 28 lbs/day factor represents the average daily ozone season emission rate for a typical remediation event initiated at the midpoint of the ozone season. As an example, emissions in a given geographic area that had 27 UST remediations over the ozone season would be calculated as follows.

$$\frac{\text{28 lbs VOC per ozone season day}}{\text{remediation event}} \quad * \quad \text{27 remediations} \quad = \quad \frac{\text{756 lbs VOC}}{\text{ozone season day}}$$

The Alternative Method is predicated on a set of emission rates developed by EPA covering common soil excavation volumes and gasoline contamination levels for leaking UST sites (EPA, 1992). Table 1 contains a summary of these data. If a user has some more site-specific information about a remediation event, they could use the table to determine an emission rate instead of relying solely on the default emission rate value.

TABLE 1.
ESTIMATED VOC EMISSION RATES FOR REMEDIATIONS OF LEAKING USTS

Project Size Quantity of Soil Removed (yd^3)	Gasoline Concentration in Soil as TPH (ppmw)	VOC Emission Rate (lbs/typical ozone season day)[a]
50	100	0.3
	1,000	2.8
	10,000	28
500	100	2.8
	1,000	28
	10,000	280
1,500	100	8.4
	1,000	84
	10,000	840

[a] This value represents the average emission rate during the ozone season for an event initiated at the midpoint of the ozone season. Source: EPA, 1992.

The data in Figure 1, a graph of “Soil Pile Average Ozone Season Emission Rates as a Function of Soil Pile Size and Initial Gasoline Concentration,” which was also developed by EPA, allows a user to estimate VOC emission rates for excavated soil volumes and contamination levels not listed in Table 1 (EPA, 1992).

The default emission rate and those in Table 1 were developed assuming that the soil contaminant was unleaded gasoline. These emission rates may not be applicable to other contaminants such as heating oil, diesel fuel and waste oil, all of which have lower volatility than gasoline, and consequently should have lower emission rates than gasoline. Applying a gasoline-based emission rate to tanks that stored less volatile substances would overestimate the emission rate for these tanks; however, all of the lower volatility contaminant may still be emitted to the air if the soil is left exposed long enough.

POINT SOURCE ADJUSTMENTS

If the Alternative Method of using the default emission rate (28 lbs per day/remediation) * total number of remediations is applied, the user should ensure that any remediations already treated as point sources are subtracted from the area wide total before applying the default rate.

ADJUSTMENTS FOR CONTROLS

The most commonly used VOC control method for UST remediation soils is to provide a physical barrier to vapor transport. The easiest barrier to use is clean soil as a cover for contaminated soil. The effectiveness of a soil cover depends on the depth of the cover and the percent of contaminated soil that can be covered. Some measurements have shown that a compacted soil cover can reduce emissions by 95%, although lateral migration of VOC can still occur (EPA, 1997). Synthetic covers are also used to control VOC emissions from on-site storage piles. Their effectiveness depends on the permeability of the cover to the vapors present and the percentage of the pile that is covered. No estimates of control efficiency from synthetic covers could be found.

Modified fire-fighting foams have also been used to control VOC emissions during soil cleanup activities. Two general types of foams are used: temporary and long-term. Temporary foams are used to provide coverage for time periods on the order of a few hours. Long-term foams can be used for a few days or even weeks. Temporary foams have been shown to achieve emission reductions of 75-95%, while long-term foams have controlled VOC emissions in excess of 99%. Water sprays have also been used on remediation soil piles. Water acts to reduce vapor transport by cooling the soil temperature and decreasing soil porosity. The VOC reduction effectiveness of water sprays has not been documented (EPA, 1997). Operational controls have also been suggested as ways to reduce VOC emissions though no data are available to quantify their effectiveness (EPA, 1997). Operational controls involve controlling the rate of excavation, the amount of contaminated soil that is left exposed, the durations piles are left uncovered, and the amount of excavation done in high wind conditions.

Some states may have unique standards mandating emission reduction techniques. One example is Bay Area Air Quality Management District (BAAQMD) Regulation 8, Organic Compounds, Rule 40, Aeration of Contaminated Soil and Removal of Underground Storage Tanks. As of June 1, 2000, Regulation 8 controls the rate of uncontrolled aeration and requires use of water spray treated with an approved vapor suppressant during soil excavation. Regulation 8 also requires soil surfaces to be covered with heavy duty plastic sheeting to minimize emissions of VOCs to the atmosphere.

SPATIAL AND TEMPORAL ALLOCATIONS

Spatial: Allocations of emissions can be apportioned accurately if the locations of leaking UST site locations are known. EPA's UST Branch recommends contacting the state in question to determine the most accurate and up-to-date information on UST remediation locations. Links to state programs can be found on the Branch's web site at www.epa.gov/swerust1/. If UST site locations are not known, then spatial allocation of emissions may be apportioned by employment for SIC Code 5541, Gasoline Service Stations.

Temporal: The emissions determined by the Preferred Method can be assumed to occur uniformly on a daily basis (24-hour day) in any month in which remediation activity takes place. The emissions estimated by the Alternative Method are applicable to the ozone season since they were developed using ambient temperature profiles occurring in the ozone season.

OTHER EMISSION CALCULATION ISSUES

None.

REFERENCES

Delaware DNREC. 2001. *Underground Storage Tank Information Locator*. Delaware Department of Natural Resources and Environmental Control. Dover, Delaware. The website can be found at the following Internet address: http://www.dnrec.state.de.us/dnrec2000/UST.asp

EPA. 1989. *Estimating Air Emissions from Petroleum UST Cleanups*. U. S. Environmental Protection Agency, Office of Underground Storage Tanks. Washington, D.C.

EPA. 1992. *VOC Emissions from Leaking Underground Storage Tanks.* Technical memorandum. U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina.

EPA. 1997. *Air Emissions from the Treatment of Soils Contaminated with Petroleum Fuels and Other Substances*. Eklund, B., et al., Radian Corporation, Austin, Texas and S. Roe, E. H. Pechan & Associates, Rancho Cordova, California. EPA Report No. EPA-600/R-97-116.

EPA. 1998a. *FAQ: What Is An Underground Storage Tank (UST) System?* U. S. Environmental Protection Agency, Office of Underground Storage Tanks. Washington, D.C. The Webpage may be found at the following Internet address: http://www.epa.gov/swerust1/

EPA. 1998b. *FAQ: Why Are UST Systems Regulated?* U. S. Environmental Protection Agency, Office of Underground Storage Tanks. Washington, D.C. The Webpage may be found at the following Internet address: http://www.epa.gov/swerust1/

EPA. 1998c. *Office Of Underground Storage Tanks.* U. S. Environmental Protection Agency, Office of Underground Storage Tanks. Washington, D.C. The Webpage may be found at the following Internet address: http://www.epa.gov/swerust1/

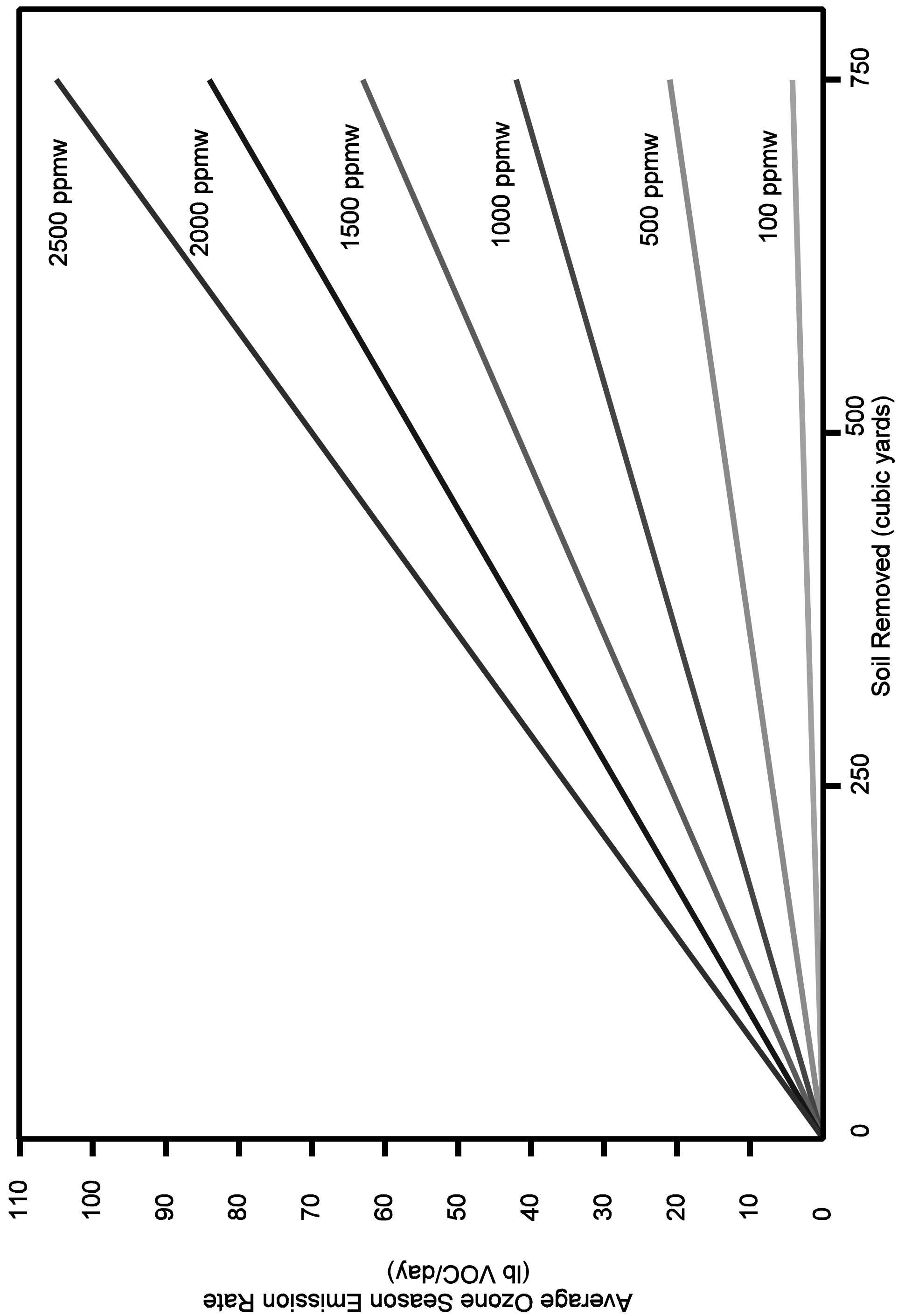

FIGURE 1. SOIL PILE AVERAGE OZONE SEASON EMISSION RATES AS A FUNCTION OF SOIL PILE SIZE AND INITIAL GASOLINE CONCENTRATION

Source: EPA. 1992